Spring 2010

Combating Requirements Instability in Space Acquisition Programs

Berton Manning
Loyola Marymount University

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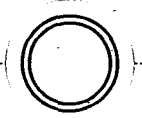


LOYOLA MARYMOUNT UNIVERSITY

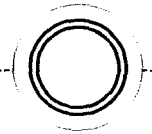
GRADUATE SYSTEMS ENGINEERING CAPSTONE PROJECT

SELP 695

BERTON MANNING

THESIS ADVISOR DR. BOHDAN OPPENHEIM

Outline



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- The Need
- Research Goals
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- Findings
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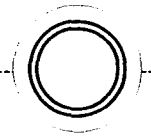
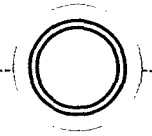
- Recommendations
- Conclusions

Author's Relevant Elements of CV



- Active Duty Air Force 98-07
  - 5 Years as program manager
  - 4 years as systems engineer at SMC
- Air Force Reserve 07-Present
  - Defense Contract Management Agency
    - SE on Missile Defense Agency contracts
- Northrop Grumman 08-09
  - Senior Mission Systems Engineer
    - Counter Space Programs
    - Classified Programs



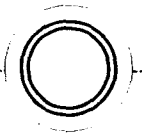
The Need

The Need – Why Care

- A review of 95 defense projects by the GAO in 2006 found that in the last ten years:
  - 85% of all DoD projects were over budget by a total of $295 billion
  - Delayed by an average of 3.5 years
- As a Result:
  - Much needed capability has been delayed or not even developed
  - Congress/American public has lost faith in the military acquisition system
  - Technology advancement has slowed
  - Reduction in the industrial base
  - Less young people willing to enter the acquisition career field

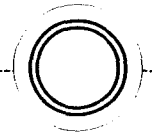
"A train wreck is coming. Runaway costs, prolonged delivery schedules and poor performance in the acquisition of major weapons amount to a form of unilateral disarmament." (*Senator John McCain, March 2009)*

The Need - What



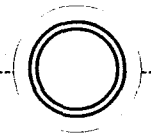
- GAO, NASA and others agencies found that a main cause for exceeding budget and schedule was requirements instability.
  - Requirements instability contributes to over 50% of all programs with budget and schedule delays
  - Drives funding instability which is the #1 cause

The DoD needs to eliminate requirements instability on its space acquisition programs

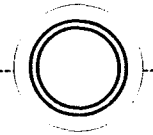


Research Goals

Research Goals

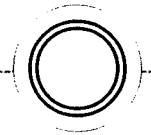


1. Study the requirements stability/instability within the AF SMC space community
2. Determine the main causes of requirements instability on the majority of space programs
3. Provide recommendations to acquisition personnel that will help eliminate requirements instability



Research Methodology

Research Methodology



- Research Steps:
  1. Interview SE personnel on three SMC programs currently experiencing requirements instability
     1. AEHF, SBIRS and SBSS
     2. Including SMC Center and contractor
  2. Analyze current documentation pertaining to requirements instability on space programs
  3. Analyze the role of the contractor community in requirements instability
  4. Determine the causes of requirements instability
  5. Develop a list of recommendations

Interviewees

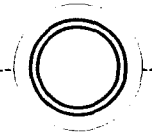
- 24 systems engineers interviewed in total
  - SMC Center = 2 SMC Chief Systems Engineers
  - Wing = 3
  - Project = 7
  - Support = 8
  - Contractor = 4

Program	Center	Wing	Project	Support	Contractor *
SMC	2				N/A
SIBRS		1	2	4	
AEHF		1	3	3	
SBSS		1	2	1	
Total	**2**	**3**	**7**	**8**	**4**

* program allocation not listed to protect privacy

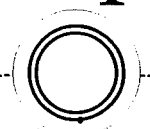
Findings

Findings Overview



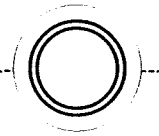
- The findings have been grouped into five following categories, and the results are discussed in this order:
  1. Acceptance of Incomplete Requirements
  2. Acceptance of Immature Technology
  3. Lack of Requirements Authority
  4. Sporadic Stakeholder Involvement
  5. Lack of Systems Engineering Expertise

Acceptance of Incomplete Requirements



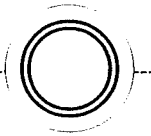
- The acceptance of incomplete requirements is the #1 reason for requirements instability
- The main blame should be placed on the current policy of Evolutionary Acquisitions:
  - Programs start knowing that their requirements are incomplete
  - Programs start as quick as possible to meet funding profiles, schedule milestones, urgent need request, politics and aggressive officers seeking promotion
  - Willingness to get a program started without knowing the value proposition
- A secondary blame is that the SMC Commander is forced to write Operational requirements just before Milestone B, which should have been finalized by AFSPC at Milestone A.
  - Undermines the acquisition system
  - Reduces accountability

Acceptance of Immature Technology



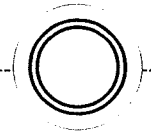
- The acceptance of immaturity technology after KDP-B (Milestone B) is causing space programs to exceed their initial cost and schedule estimates by more than 33%
  - Mature technology has the average cost growth of 5%
- The assigned roles of the Air Force Research Laboratory (AFRL) and SMC are not consistent and followed uniformly. It is supposed to be as follows:
  - AFRL develops mature technology
  - SMC executes programs with mature technology
- Regrettably the majority of SMC program do not follow this pattern
  - Therefore, SMC system engineers are forced to spend most of their time focusing on maturing technology instead of performing basic SE tasks
  - Leaving inadequate time for requirements management/control

Lack of Requirements Authority



- Congress and the Pentagon hold Air Force leadership accountable for schedule and funding profiles, not requirements.
- Therefore the requirements creation receives low priority within the Air Force.
- 54% of SMC systems engineers interviewed cite poor requirements authority.
- Air Force and SMC are experiencing a shortage of experienced systems engineers with the proper domain knowledge who have the power to fight for more authority.
  - SMC received fewer senior officers than the rest of the Air Force "7% of its engineers at the rank of lieutenant colonel compared to 10% for all Air Force."
  - Systems engineers at the ranks of Lt. Colonel and above with 14-20 years of experience are regarded as experienced

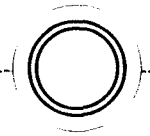
Sporadic Stakeholder Involvement



- In complex programs close coordination among stakeholders is critical for success
- 90% of AF programs are initiated by industry marketing without identifying users, therefore proper stakeholder involvement is impossible
- On the remaining 10% of the programs, user involvement is also poor.
- Programs encounter a lot of requirements instability from key stakeholders conducting drive-by changes.
- The Program Sponsor and User are the least involved of any stakeholder.

Lack of Systems Engineer Experience

- Congress and the Pentagon hold Air Force leadership accountable for schedule and funding profiles, not requirements.
- In consequence the SE career is less conducive to officer's careers than the financial career of a program manager.
- As a result the number of SE at SMC has been steadily decreasing.
- Starting 1996 with the policy: Total System Performance Responsibility (TSPR).
  - Reduction of SEs by 75% from 1000 in 1990 to 250 in 2005
  - In 1990, the DoD spent $80 billion a year on weapons systems and had an acquisition workforce of 500,000 people. Today, they spend $90 billion a year with an acquisition workforce of 200,000 people.
  - The overall number of officers certified in acquisition management has dropped from 28 percent in 1996 to 15 percent in 2005.
  - Currently 37% of all critical acquisition positions are vacant according to the GAO
- The training development for SEs officer is inadequate for the needs.



Case Studies

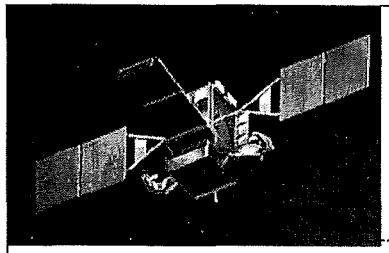
Findings – Case Studies

- Each program exhibits all requirements instability causes but only the leading ones are listed
  - Table below illustrates the main complaints

Requirements Instability Causes	Center	SIBRS	AEHF	SBSS
Acceptance of Immature Technology		X		X
Acceptance of Incomplete Requirements			X	
Lack of Requirements Authority	X	X		
Sporadic Stakeholder Involvement			X	
Lack of systems engineering expertise	X	X		X

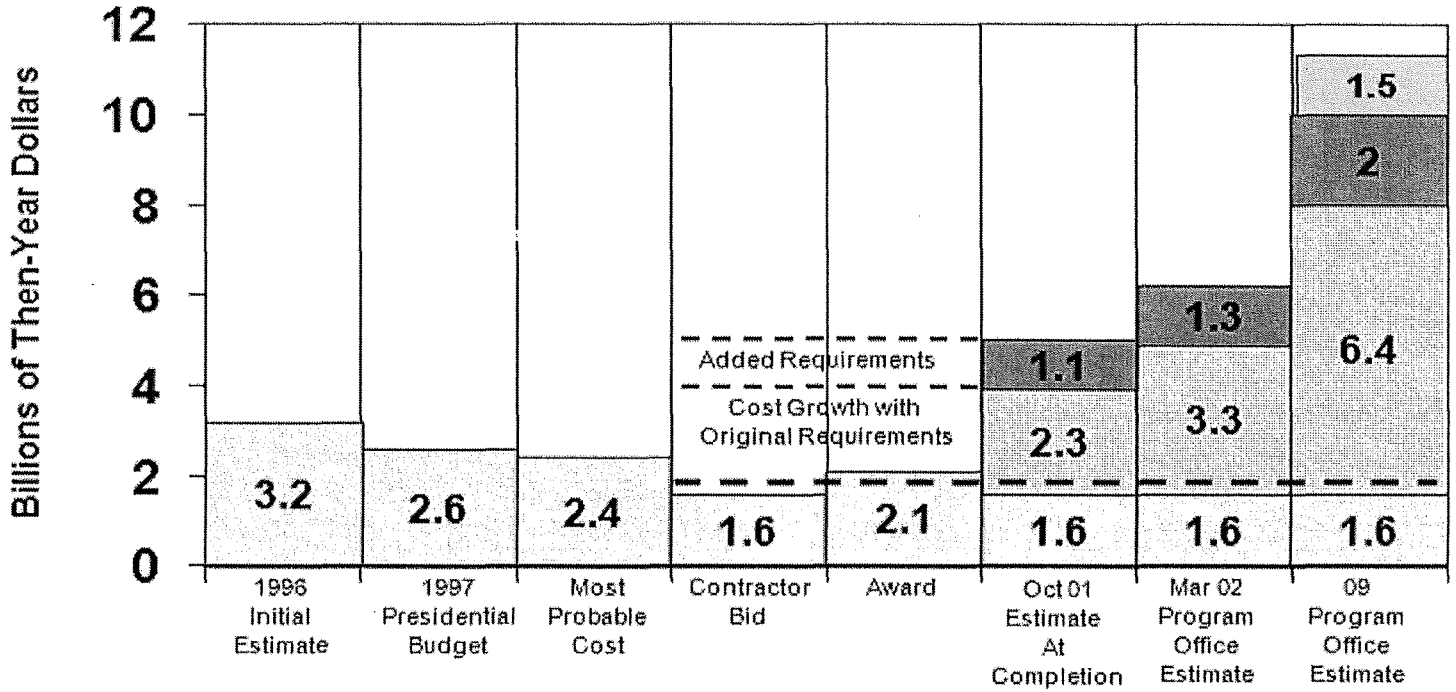
Case Study – SMC Center

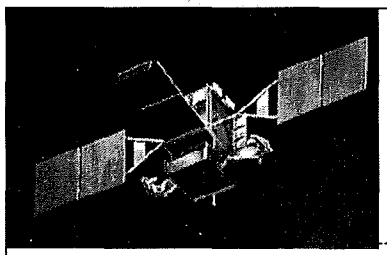
- Lack of Requirements Authority
  - The Chief Systems Engineer and every systems engineer interviewed could not identify a single person who is ultimately accountable for the requirements
  - Everyone is focused on cost and schedule
  - Systems engineers are not focused on what is really important in the requirements
- Lack of Systems Engineering Expertise
  - Inadequate training and development
  - The lack of mentoring from senior engineers
  - The lack of manpower and funding to develop a SE curriculum.



Case Study - SBIRS

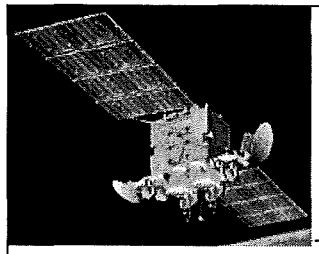
- The original cost estimate = $3.2 Billion
- Current cost estimated = $11.5 Billion.
- Original completion 2002, now estimated 2012





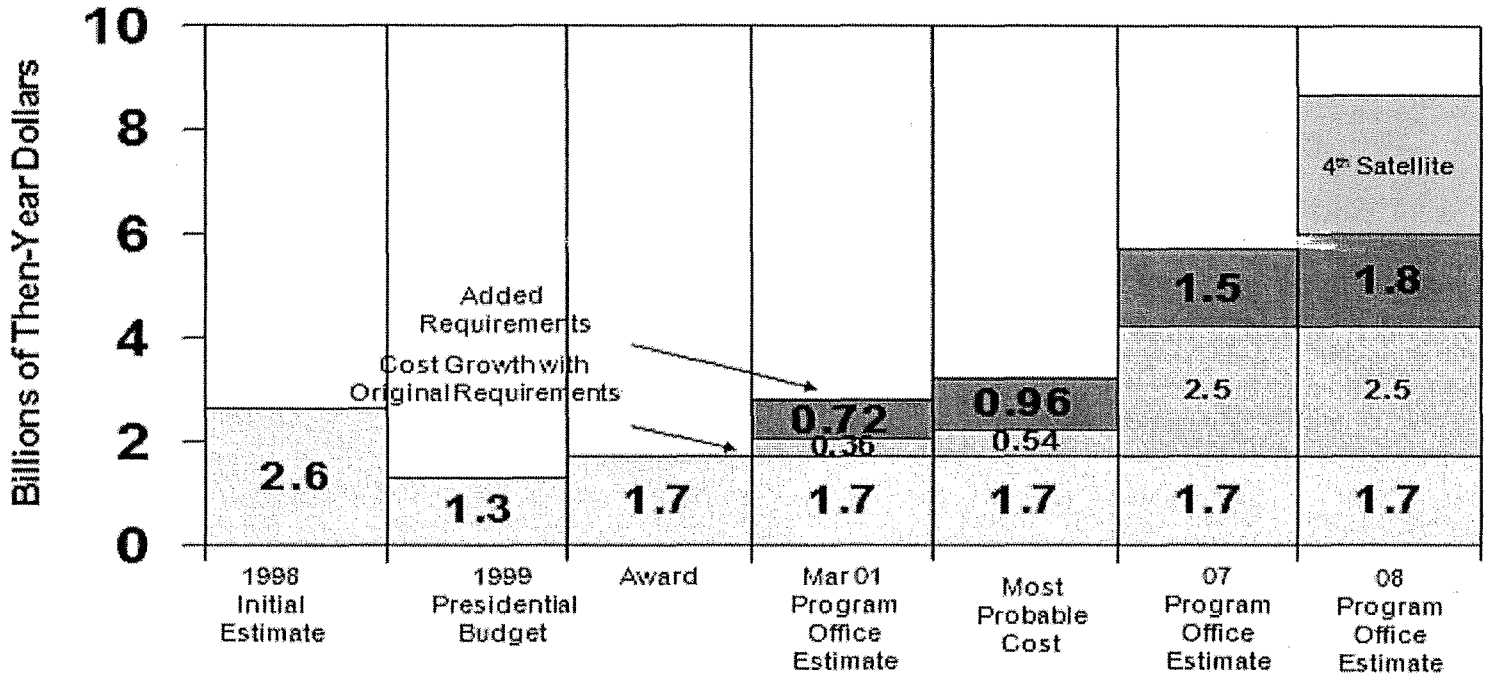
Case Study - SBIRS

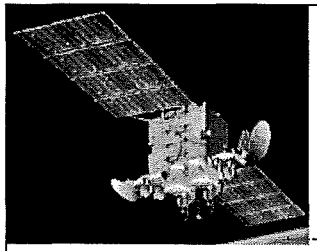
- Lack of requirements authority
  - SBIRS has 19 Key Performance Parameters (KPP) and 12,600 system level requirements. This is five times more than the typical DoD program
  - Requirements growth has become so pervasive that it is viewed as an expected and acceptable occurrence on the program
- Lack of systems engineering expertise
  - The program does not have a rigid configuration control process to manage and control their requirements.
- Acceptance of immature technology
  - SBIRS three critical technologies were immature at the start of the program: the main infrared payload sensor, the thermal management system and the onboard processor



Case Study - AEHF

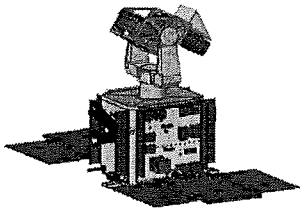
- The original cost estimate = $2.7 Billion
- Current cost estimated = $9 Billion.
- Original completion 2004, now estimated 2009.





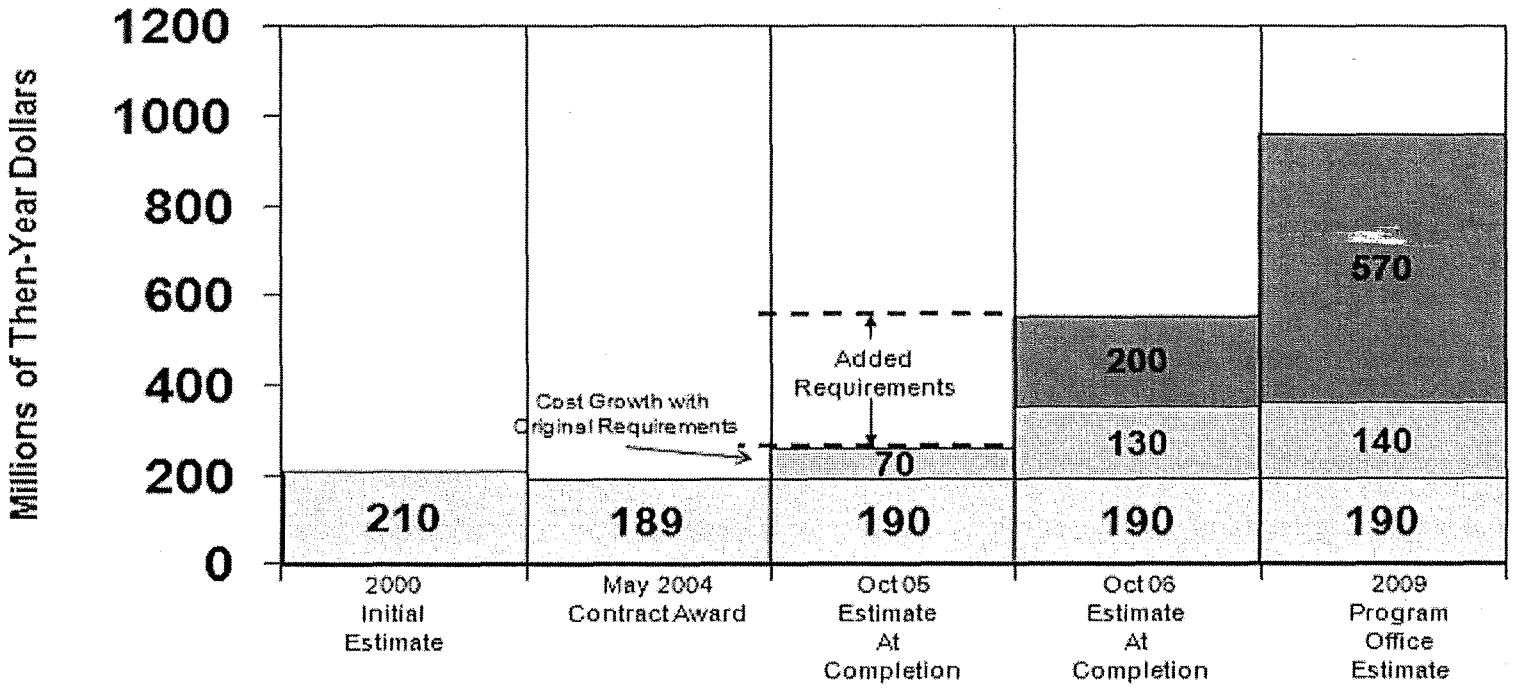
Case Study - AEHF

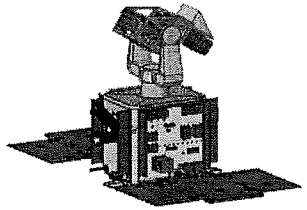
- Lack of stakeholder involvement
  - Stakeholder involvement on the program has grown to include the Navy, Army and Intelligence
  - Increased the number of KPP's from 6 to 13
- Acceptance of incomplete requirements
  - The program was knowingly awarded with incomplete requirements because the Air Force needed to rapidly fill a gap in capability left by a Milstar launch failure
  - The AEHF program office falsely assumed that the satellite payload weight would be constant and there would be no growth in requirements.
    - Payload weight more than doubled
    - Additional phased array antenna capabilities were added



Case Study - SBSS

- The original cost estimate = $189 Million
- Current cost estimated = $900 Million.
- Original completion 2007, now estimated Jan 2010

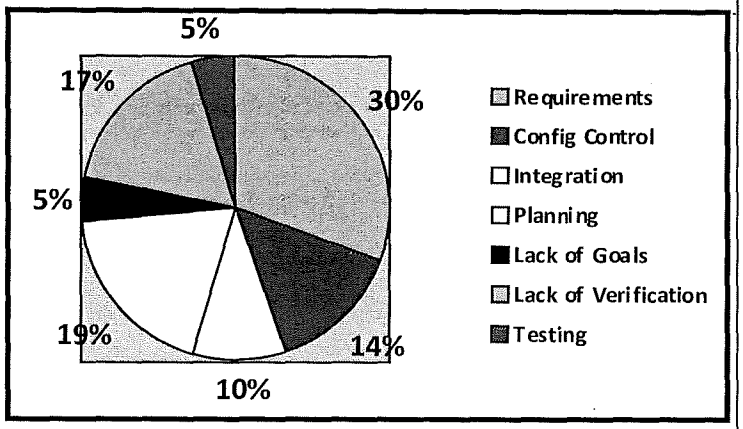




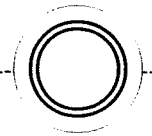
Case Study - SBSS

- Acceptance of immature technology
  - Immature spacecraft stabilization technology was accepted at the beginning of the program
- Lack of systems engineering expertise
  - The prime contractor subcontracted the program and the program office did not understand this relationship and created mistrust
  - The program office has usurped design responsibilities from the prime contractor on occasions causing major rework
  - Currently, the average officer's SE experience is between 4 – 6 years

Summary of Problems

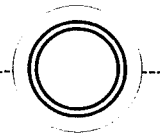


- Ambiguous Requirements
  - Requirements are disconnected from upper and lower level requirements.
- Loss of Configuration Control
  - Many programs at SMC accept changes to their program baseline without going through a Configuration Control Board (CCB).
- Inadequate Integration and Interface Analysis
  - Interface control standards are out of date at the program offices
- Lack of Systems Engineering Planning
  - Inadequate understanding of the criticality of a SEP.
- Lack of goals
  - There are no SE goals set by leadership. This creates a chaotic environment because without goals, it is virtually impossible for the SE staff to seek improvements.
- Lack of verification
  - The program office has the tendency to follow what the contractors say. It needs to get into the routine of, "trust but verify".
- Inadequate Testing
  - There is a lack of rigorous testing by both, SMC and Contractor, especially of software, which causes re-work costs. Both the program office and contractor game the test without really finding the problems.



Recommendations

Recommendations



- Senior Level Recommendations
  - Mandate stakeholder involvement
  - Elevate systems engineering to a leadership position
  - Finalize operational requirements before arrival at SMC
  - Establish an unbias space requirements czar
  - Update KDP-B entrance criteria
  - Establish an aggressive systems engineering training program
- Program Level Recommendations
  - Freeze requirements at RFP
  - Freeze technology at contract award
  - Let the laboratories develop technology
  - Develop a lessons learned process

Senior Level Recommendations

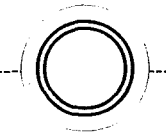
- For senior leadership to address overarching SE problems
- The senior level recommendations are for:

SMC

DoD

Air Force

Mandate Stakeholder Involvement

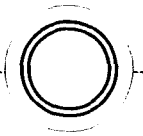


- Senior leadership needs to mandate that all stakeholders be intensely involved in a program from the beginning
- Steps to be taken:
  1. Mandate stakeholder identification before KDP-A
  2. Have a signed charter by all stakeholders prior to requirements development and
  3. Mandate that all changes to the requirements baseline be signed-off by all stakeholders.

Elevate Systems Engineering to a Leadership Position

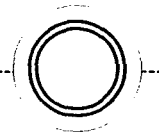
- The SMC commander must mandate that Systems engineer must have RAA for the technical program success
- "Wing" program commanders should structure their organizations so that the program chief systems engineer and program manager are co-equal and report directly to the Wing Commander.
- Senior leadership should be responsible for full implementation of SE polices and practices throughtout the chain of command.

Finalize Operational Requirements



- Senior leadership must mandate that AFSPC finalize all operational level requirements at KDP-A.
- SMC leadership should not accept any new programs that do not have a finalized Initial Capability Document (ICD) and Capability Development Document (CDD)
- The ICD and CDD must be signed off by AFSPC, the user, Joint Requirements Council (JROC), Space Requirements Czar and all critical stakeholders prior to acceptance by SMC.
  - This is the only way to prevent programs from starting with incomplete requirements.
- Air Force leadership must ensure that the requirements development organization at AFSPC has the proper resources to write operational level requirements

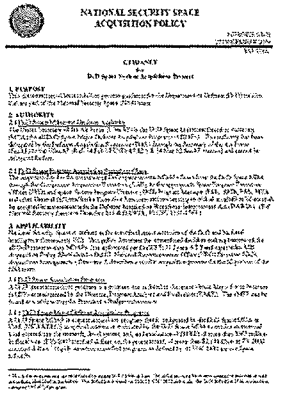
Establish an unbiased Space Requirements Czar



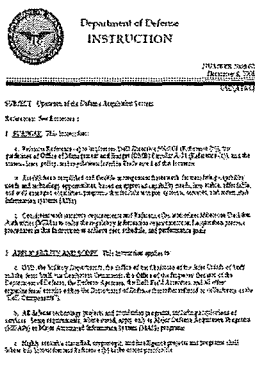
- OSD should establish an unbiased Space Requirements Czar
  - The Czar should be a permanent stakeholder on all major SMC programs and be a civilian appointed by OSD.
  - The Czar should report directly to the Under Secretary of Defense for Space Acquisitions and not to the Air Force
- The main goal of the Czar is to ensure requirements stability on all major SMC programs.
- Update the Defense Acquisition Regulation 5000.2 and National Security Space (NSS) 03-01 entrance requirements to include approval of operational and system level requirements by the Czar.

Update KDP-B Entrance Requirements

- Senior Leadership needs to update the Milestone B entrance requirements to include the following:
- **KDP-B and 5000.2 Milestone B entrance requirements**
  - All stakeholders have approved milestone B entrance requirements;
  - The requirements for the program have been finalized;
  - The Program Office is adequately staffed with trained personnel;
  - The Space Requirements Czar has approved all finalized requirements

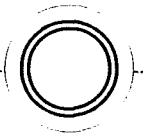


NATIONAL SECURITY SPACE ACQUISITION POLICY



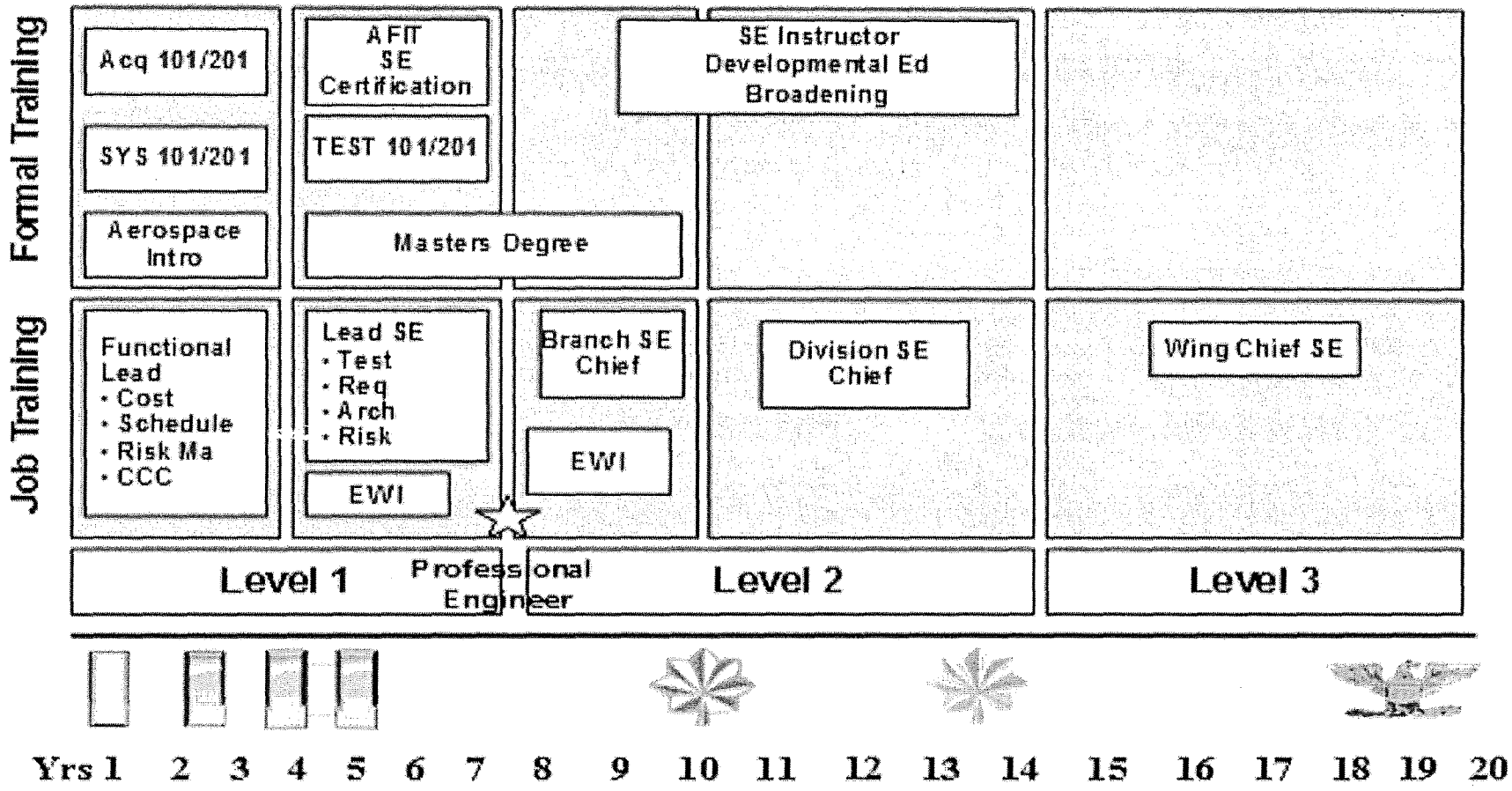
Department of Defense INSTRUCTION

Establish a SE Training Program

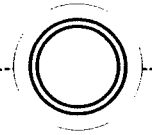


- Develop a comprehensive SE development and training program.
- Every Air Force engineer should be expected to pursue a Professional Engineer (PE) Certification in Systems Engineering.
- The Air Force should create a new core Air Force Specialty Code (AFSC) for SE.
- Establish the proposed Air Force Center of System Engineering Excellence at AFIT.
- Allocate money and manpower to SE training.

Establish an SE Training Program

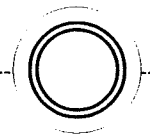


Program Level Recommendations



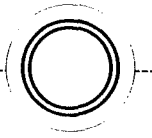
- Eliminate the bad practices that are causing requirements instability.
- Program level recommendations are meant for:
  - Systems Engineers
  - Program Managers
  - and other program personnel

Freeze Requirements at RFP



- Operational and system level requirements must be finalized at Request for Proposal (RFP) release.
  - Finalized requirements will help program personnel write the best RFP possible
  - Freezing the requirements at RFP release will allow contractors to truly understand what is needed by the government and propose the best possible solution
- Senior level leadership needs to make sure operational requirements are written and finalized prior to being accepted by SMC.

Freeze Technology at Contract Award

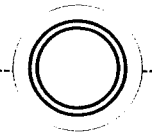


- All programs should freeze technology selection at contract award and accept only technology that is at Technical Readiness Level (TRL) level 6 or above.
  - Accepting only TRL 6 and above will eliminate the need for programs to spend money and time to mature technology
- In the 2006 Defense Authorization Act, Congress passed a law that now requires the DoD to certify that all technology is demonstrated to a specific maturity level before being allowed into KDP-B or Milestone B, System Development.
  - This statement has specific ambiguity that a "truck can be driven through"

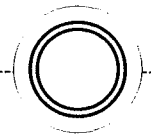
Let the Laboratories Develop Technology

- The program office should not be conducting technology development.
- A representative from AFRL should reside in all program offices to facilitate a better relationship.
  - Utilize AFRL to explore and mature any immature technology that they deem might be beneficial for a future planned capability
  - But will not drive future programs

Develop Lessons-Learned Process

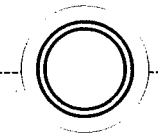


- All program office's at SMC need to develop and implement a capable lessons-learned process.
- Develop a knowledge/data base which is searchable and user friendly.
- Designate one person to lead the lessons-learned program on each program.
- Steps
  1. Capture relevant data from past and current space programs
  2. Catalogue the data into easy to use categories
  3. Communicating the data in the form of reports, training material pamphlets, white papers or other
  4. Incorporate the data into the development process and
  5. Institutionalize the lessons learned process into the acquisition process.



Conclusion

Conclusion



- $285 billion dollars have been wasted in last ten years
- Comprehensive study has been performed to study the reason(s) for requirements instability
- Five critical reasons have been identified
  1. Acceptance of Incomplete Requirements
  2. Acceptance of Immature Technology
  3. Lack of Requirements Authority
  4. Sporadic Stakeholder Involvement
  5. Lack of Systems Engineering Expertise
- Specific recommendation were created that if followed should eliminate the problem